

IN THE CLAIMS:

Claims 53 – 59, 63 – 66, and 71 are amended, as follows:

Claims 1 - 10 (cancelled).

11. (original) A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter sections that are provided corresponding to the first and second microphones for subjecting an audio signal supplied to the first loudspeaker to convolution calculations so as to produce first and second echo cancel signals, respectively;

third and fourth filter sections that are provided corresponding to the first and second microphones for subjecting another audio signal supplied to the second loudspeaker to convolution calculations so as to produce third and fourth echo cancel signals, respectively;

a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first microphone; and

a second subtracting section that performs echo cancellation by subtracting said second and fourth echo cancel signals from another collected audio signal of the second microphone, wherein

said stereo echo canceller further comprises a transfer function calculating section that respectively derives filter characteristics corresponding to transfer functions of said four audio transfer systems based on a cross-spectrum calculation between a

sum signal and difference signal of stereo audio signals to be reproduced by said respective loudspeakers and the collected audio signals of said respective microphones, thereby to set said derived filter characteristics to corresponding ones of said first to fourth filter sections, respectively.

12. (original) A stereo echo canceller as recited in claim 11, further comprising:
an input section that inputs said stereo audio signals;
a sum/difference signal producing section that produces said sum signal and said difference signal of the stereo audio signals inputted from said input section; and
a main signal transmission system that transmits the stereo audio signals inputted from said input section to said respective loudspeakers without passing through said sum/difference signal producing section,

wherein said transfer function calculating section derives the filter characteristics corresponding to the transfer functions of said four audio transfer systems based on the cross-spectrum calculation between the sum signal and difference signal produced by said sum/difference signal producing section and the collected audio signals of said respective microphones, and sets the derived filter characteristics to corresponding ones of said first to fourth filter sections, respectively.

13. (original) A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter sections that are provided corresponding to the first and second microphones for subjecting an audio signal

supplied to the first loudspeaker to convolution calculations so as to produce first and second echo cancel signals, respectively;

third and fourth filter sections that are provided corresponding to the first and second microphones for subjecting another audio signal supplied to the second loudspeaker to convolution calculations so as to produce third and fourth echo cancel signals, respectively;

a first subtracting section performs echo cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first microphone; and

a second subtracting section that performs echo cancellation by subtracting said second and fourth echo cancel signals from another collected audio signal of the second microphone, wherein

said stereo echo canceller further comprises a transfer function calculating section respectively derives estimated errors of transfer functions of said four audio transfer systems based on a cross-spectrum calculation between respective one of a sum signal and a difference signal of stereo audio signals to be reproduced by said respective loudspeakers and respective one of echo cancel error signals obtained by subtracting the corresponding echo cancel signals from the collected audio signals of said two microphones, thereby to update filter characteristics of said first to fourth filter sections to values that cancel said estimated errors, respectively.

14. (original) A stereo echo canceller as recited in claim 13, further comprising:

an input section that inputs said stereo audio signals;

a sum/difference signal producing section that produces said sum signal and said difference signal of the stereo audio signals inputted from said input section; and

a main signal transmission system that transmits the stereo audio signals inputted from said input section to said respective loudspeakers without passing through said sum/difference signal producing section,

wherein said transfer function calculating section derives the estimated errors of the transfer functions of said four audio transfer systems based on the cross-spectrum calculation between the sum signal and difference signal produced by said sum/difference signal producing section and the respective echo cancel error signals, and updates the filter characteristics of said first to fourth filter sections to the values that cancel said estimated errors, respectively.

15. (original) A stereo echo canceller as recited in claim 13, further comprising a correlation detecting section that detects a correlation between the sum signal and the difference signal of said stereo audio signals, and that stops the updating of said filter characteristics when a value of said correlation is no less than a predetermined value.

Claims 16 – 20 (withdrawn)

21. (original) A stereo sound transfer apparatus associated to two spaces each forming said four audio transfer systems, wherein the stereo echo canceller recited in claim 11 is arranged in each space, so that the stereo audio signals, which have been echo-canceled by said stereo echo cancellers, are transmitted between said two spaces.

Claims 22 - 40 (cancelled)

Claims 41 – 48 (withdrawn).

Claims 49 - 52 (cancelled).

53. (currently amended) A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and ~~one or a plurality of microphones~~ at least one microphone for forming a plurality of audio transfer systems,

the method comprising:

inputting multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said at least one microphone[[s]] through the audio transfer systems;

estimating individual transfer functions of said plurality of said audio transfer systems ~~or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions~~ so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said [[the]] multi-channel audio signals to be reproduced by said respective loudspeakers ~~or a plurality of composite signals obtained by suitably combining said multi-channel audio signals~~; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said ~~one or plurality of~~ at least one microphone[[s]], ~~or from a plurality of composite signals obtained by suitably combining said individual collected audio signals~~, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving said individual

transfer functions of the respective audio transfer systems ~~or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions~~, thereby setting said corresponding filter characteristics.

54. (currently amended) A multi-channel echo cancel method as recited in claim 53, wherein calculation is conducted for respectively deriving the individual transfer functions of the respective audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum calculation between the plurality of the low-correlation composite signals and the individual collected audio signals of the at least one microphone~~s~~, ~~or the plurality of the composite signals obtained by suitably combining said individual collected audio signals~~.

55. (currently amended) A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers ~~and one or a plurality of microphones~~ at least one microphone for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are collected by said at least one microphone~~[[s]]~~,

the method comprising: estimating individual transfer functions of said plurality of said audio transfer systems ~~or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions~~ so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter

characteristics to corresponding ones of said multi-channel audio signals to be reproduced by said respective loudspeakers ~~or a plurality of composite signals obtained by suitably combining said multi-channel audio signals;~~ and

subtracting said echo cancel signals from corresponding individual collected audio signals of said ~~one or plurality of~~ at least one microphone[[s]], ~~or from a plurality of composite signals obtained by suitably combining said individual collected audio signals,~~ thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving said individual transfer functions of the respective audio transfer systems ~~or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions,~~ thereby setting said corresponding filter characteristics,

wherein calculation is conducted for respectively deriving the individual transfer functions of the respective audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum calculation between the plurality of the low-correlation composite signals and the individual collected audio signals of the at least one microphone[[s]], ~~or the plurality of the composite signals obtained by suitably combining said individual collected audio signals,~~ and wherein

the calculation of respectively deriving the individual transfer functions of said plurality of the audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ is performed by combining said multi-channel audio signals through ~~addition or subtraction~~ arithmetic operation to produce a plurality of low-correlation composite signals having a lower correlation with each other than that among said multi-channel audio signals, deriving cross spectra by the cross-spectrum calculation between said plurality of the low-correlation composite signals and the individual collected audio signals of the at least one microphone[[s]], ~~or the plurality of the composite signals obtained by suitably combining said individual collected audio signals~~, and ensemble-averaging each of the cross spectra in a predetermined time period for deriving the individual transfer functions of said plurality of the audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~.

56. (currently amended) A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers ~~and one or a plurality of microphones~~ at least one microphone for forming a plurality of audio transfer systems,

the method comprising:

inputting multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said at least one microphone[[s]] through the audio transfer systems;

estimating individual transfer functions of said plurality of said audio transfer systems ~~or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions~~ so as to set corresponding filter characteristics,

respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by said respective loudspeakers or a plurality of composite signals obtained by suitably combining said multi-channel audio signals; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said at least one ~~or plurality of~~ microphones, ~~or from a plurality of composite signals obtained by suitably combining said individual collected audio signals~~, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving estimated errors of said individual transfer functions of the respective audio transfer systems or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions, thereby updating said corresponding filter characteristics to values that cancel the estimated errors.

57. (currently amended) A multi-channel echo cancel method as recited in claim 56, wherein calculation is conducted for respectively deriving the estimated errors of the individual transfer functions of the respective audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum

calculation between the plurality of the low-correlation composite signals and echo cancel error signals obtained by subtracting the echo cancel signals from the corresponding individual collected audio signals of said ~~one or plurality of the~~ at least one microphones, ~~or from the plurality of the composite signals obtained by suitably combining said individual collected audio signals.~~

58. (currently amended) A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and ~~one or a plurality of microphones~~ at least one microphone for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are collected by said at least one microphone[[s]],

the method comprising:

estimating individual transfer functions of said plurality of said audio transfer systems ~~or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions~~ so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by said respective loudspeakers ~~or a plurality of composite signals obtained by suitably combining said multi-channel audio signals; and~~

subtracting said echo cancel signals from corresponding individual collected audio signals of said ~~one or plurality of~~ at least one microphone[[s]], ~~or from a plurality of composite signals obtained by suitably combining said individual collected audio~~

signals, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving estimated errors of said individual transfer functions of the respective audio transfer systems ~~or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions~~, thereby updating said corresponding filter characteristics to values that cancel the estimated errors,

wherein calculation is conducted for respectively deriving the estimated errors of the individual transfer functions of the respective audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum calculation between the plurality of the low-correlation composite signals and echo cancel error signals obtained by subtracting the echo cancel signals from the corresponding individual collected audio signals of said ~~one or plurality of the~~ at least one microphones, ~~or from the plurality of the composite signals obtained by suitably combining said individual collected audio signals~~, and

wherein the calculation of respectively deriving the estimated errors of the individual transfer functions of said plurality of the audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ is performed by combining said multi-channel audio signals through

~~addition or subtraction~~ an arithmetic operation to produce a plurality of low-correlation composite signals having a lower correlation with each other than that among said multi-channel audio signals, deriving cross spectra by the cross-spectrum calculation between said plurality of the low-correlation composite signals and the echo cancel error signals obtained by subtracting the echo cancel signals from the corresponding individual collected audio signals of said ~~one or plurality of the~~ at least one microphone[[s]], ~~or from the plurality of the composite signals obtained by suitably combining said individual collected audio signals,~~ and ensemble-averaging each of the cross spectra in a predetermined time period for deriving the estimated errors of the individual transfer functions of said plurality of the audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual~~ transfer functions.

59. (currently amended) A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and ~~one or a plurality of~~ microphones at least one microphone for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are collected by said at least one microphone[[s]],

the method comprising:

estimating individual transfer functions of said plurality of said audio transfer systems ~~or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions~~ so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by said respective loudspeakers or ~~a plurality of composite signals obtained by suitably combining said multi-channel audio signals~~; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said ~~one or plurality of~~ at least one microphones, ~~or from a plurality of composite signals obtained by suitably combining said individual collected audio signals~~, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving estimated errors of said individual transfer functions of the respective audio transfer systems ~~or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions~~, thereby updating said corresponding filter characteristics to values that cancel the estimated errors, and

wherein the correlation between said plurality of said low-correlation composite signals is detected and, when a value of said correlation is no less than a predetermined value, the updating of said filter characteristics is suspended.

60. (previously presented) A multi-channel sound transfer method associated to two spaces each forming said plurality of said audio transfer systems, wherein the multi-channel echo cancel method recited in claim 53 is carried out respectively in the two spaces, so that the multi-channel audio signals, which have been echo-canceled by

performing said method, are transmitted between said two spaces.

Claims 61 and 62 (withdrawn).

63. (currently amended) A transfer function calculation apparatus being associated to a space provided therein with a plurality of loudspeakers and ~~one or a plurality of microphones~~ at least one microphone for forming a plurality of audio transfer systems, and being capable of estimating individual transfer functions of said plurality of audio transfer systems ~~or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions~~, the apparatus comprising:

an input section that inputs multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said at least one microphone[[s]] through the audio transfer systems;

a providing section that provides reference signals as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that between said multi-channel audio signals; and

a calculation section that estimates the individual transfer functions of the respective audio transfer systems ~~or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions~~ based on the determined reference signals.

64. (currently amended) A transfer function calculation apparatus as recited in claim 63, wherein the calculation section respectively derives the individual transfer functions of the respective audio transfer systems ~~or the plurality of said composite~~

~~transfer functions obtained by suitably combining said individual transfer functions,~~
using as the reference signals the set of the plurality of the low-correlation composite
signals, such that calculation of respectively deriving the individual transfer functions of
the respective audio transfer systems ~~or the plurality of said composite transfer~~
~~functions obtained by suitably combining said individual transfer functions~~ is based on a
cross-spectrum calculation between the plurality of said low-correlation composite
signals and individual collected audio signals of the at least one microphones, ~~or a~~
~~plurality of composite signals obtained by suitably combining said individual collected~~
~~audio signals.~~

65. (currently amended) A transfer function calculation apparatus being
associated to a space provided therein with a plurality of loudspeakers and ~~one or a~~
~~plurality of microphones~~ at least one microphone for forming a plurality of audio transfer
systems through which multi-channel audio signals having a correlation with each other
are reproduced by said respective loudspeakers and are collected by said
microphones, and being capable of estimating individual transfer functions of said
plurality of audio transfer systems ~~or a plurality of composite transfer functions obtained~~
~~by suitably combining said individual transfer functions~~, the apparatus comprising:

a providing section that provides reference signals as a set of a plurality of low-
correlation composite signals which correspond to signals obtained by suitably
combining said multi-channel audio signals and which have a lower correlation with
each other than that between said multi-channel audio signals; and

a calculation section that estimates the individual transfer functions of the
respective audio transfer systems ~~or the plurality of the composite transfer functions~~

~~obtained by suitably combining said individual transfer functions~~ based on the determined reference signals,

wherein the calculation section respectively derives the individual transfer functions of the respective audio transfer systems ~~or the plurality of said composite transfer functions obtained by suitably combining said individual transfer functions,~~ using as the reference signals the set of the plurality of the low-correlation composite signals, such that calculation of respectively deriving the individual transfer functions of the respective audio transfer systems ~~or the plurality of said composite transfer functions obtained by suitably combining said individual transfer functions~~ is based on a cross-spectrum calculation between the plurality of said low-correlation composite signals and individual collected audio signals of the at least one microphones, ~~or a plurality of composite signals obtained by suitably combining said individual collected audio signals,~~ and

wherein the providing section combines said multi-channel audio signals through ~~addition or subtraction~~ an arithmetic operation to produce said plurality of said low-correlation composite signals having a lower correlation with each other than that between said multi-channel audio signals, such that the calculation section derives cross spectra based on said cross-spectrum calculation between said plurality of said low-correlation composite signals and the individual collected audio signals of the at least one microphone[[s]], ~~or the plurality of composite signals obtained by suitably combining said individual collected audio signals,~~ and ensemble-averages the respective cross spectra in a predetermined time period for deriving the individual transfer functions of said plurality of said audio transfer systems ~~or the plurality of said~~

~~composite transfer functions obtained by suitably combining said individual transfer functions.~~

66. (currently amended) A transfer function calculation apparatus as recited in claim 64, wherein the providing section produces a plurality of uncorrelated composite signals mutually orthogonal as the reference signals by applying a principal component analysis to said multi-channel audio signals, such that the calculation section derives cross spectra based on said cross-spectrum calculation between said plurality of said uncorrelated composite signals and the individual collected audio signals of the ~~microphones~~ at least one microphone, and ensemble-averages the respective cross spectra in a predetermined time period for deriving the individual transfer functions of said plurality of said audio transfer systems.

Claims 67 – 68 (withdrawn)

69. (previously presented) A multi-channel echo channel method as recited in claim 53, wherein the multi-channel audio signals being inputted from an outside and having a correlation with each other are reproduced by said respective loudspeakers without lowering the correlation of the inputted multi-channel audio signals.

70. (previously presented) A multi-channel echo cancel method as recited in claim 53, wherein the multi-channel audio signals being inputted from an outside and having a correlation with each other are provisionally modulated to lower the correlation, then demodulated to restore the correlation , and thereafter reproduced by said respective loudspeakers.

71. (currently amended) A multi-channel echo cancel method as recited in claim 70, wherein the multi-channel audio signals are provisionally modulated to lower the

correlation by one or first or second operations, the first operation adding and subtracting the multi-channel audio signals with each other, [[or by]] the second operation orthogonalizing the multi-channel audio signals with each other.